Anti-Microbial Activity of Military-Issue Clothing Treated with Reactive Materials

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1Lt Eric Proudfoot
Air Force Research Laboratory
Materials & Manufacturing Directorate
Tyndall AFB, FL

1. Multiple Threats = Multiple Solutions

2. Chloramine-based Reactive Materials

3. Quaternary Amine-based Reactive Materials

4. Future Directions and Conclusions

A Chronic Problem

“…During the Gulf War *seven out of ten* Army casualties were *not combat-related*.

The majority of disease-related casualties were caused by *personal hygiene* problems.”

- Force Protection Battlelab Initiative, Sept. 2001

Why Antimicrobial Undergarments?

-There's more out there than hostile combatants

Mitigatable Risks to Deployed Personnel

Microorganisms	Disease
Escherichia coli	Gastroenteritis
Staphylococcus aureus	Abscesses, wound infection
Salmonella choleraesuis	Gastroenteritis
Shigella	Gastroenteritis
Candida albicans	Yeast, diaper rash
Brevibacterium	Diaper rash
Pseudomonas aeruginosa	Skin & lung infection
Tricophyton mentagrophytes	Fungus, Athlete's Foot & Jock Itch
Vancomycin-resist. Enterococcus	Antibiotic resistant bacteria
Staphylococcus epidermidis	Foot odor

mentagrophytes & Jock Itch
Vancomycin-resist. Antibiotic resistant

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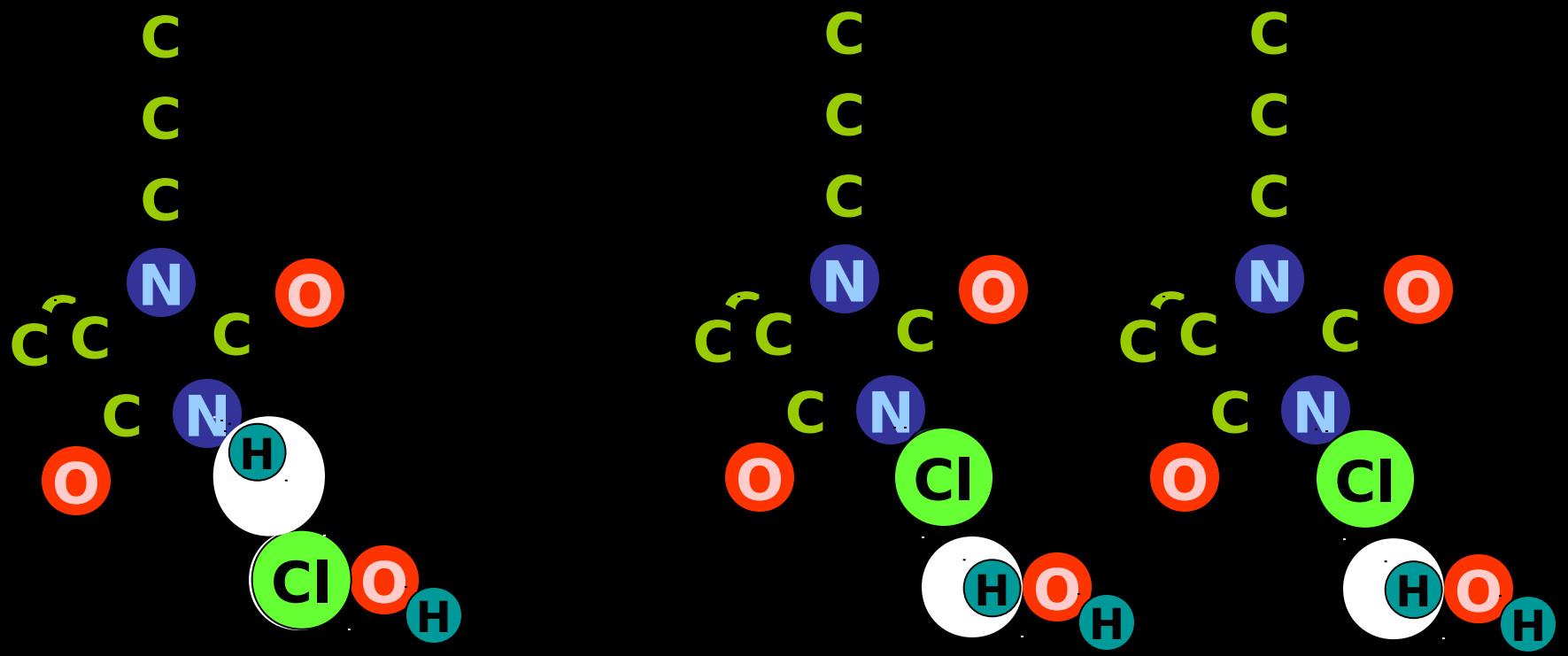
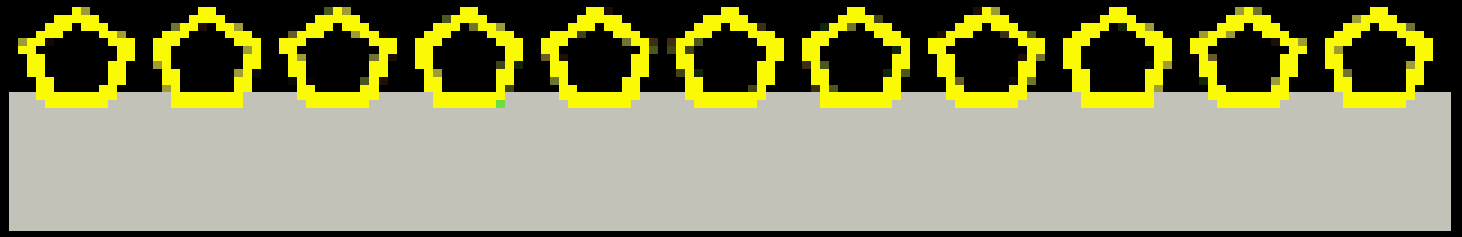
Chloramines Technology



Chloramine Benefits

- Easy to incorporate into textiles
- Re-chargeable with small qty of Cl- (ex. tap water)
- Relatively safe to user (toxicity, hypersensitivity, etc)
- Cheap to manufacture
- Good protection from biologicals

Regenerable Protection



Chloramine Results

- Low concentration of ADMH – Staph kill
- *Klebsiella* (capsule former) – 3%
- *Aspergillus* & *Candida* – need to determine lowest ADMH level level
- Vegetative vs. spore form of BG

Test Data for Chloramines

Method AATCC 100

ORGANISM	INITIAL CHALLENGE LOAD	MINIMUM % ADMH REQ'D FOR COMPLETE KILL
S.aureus	1.5×10^5	0.5%
K.pneumoniae	2.9×10^6	3.0%
A.niger	1.6×10^5	3.0%
C.albicans	1.7×10^4	3.0%*
B.atrophaeus †	3.0×10^6	-No Kill-

† *spores*

* Not tested against lower conc.

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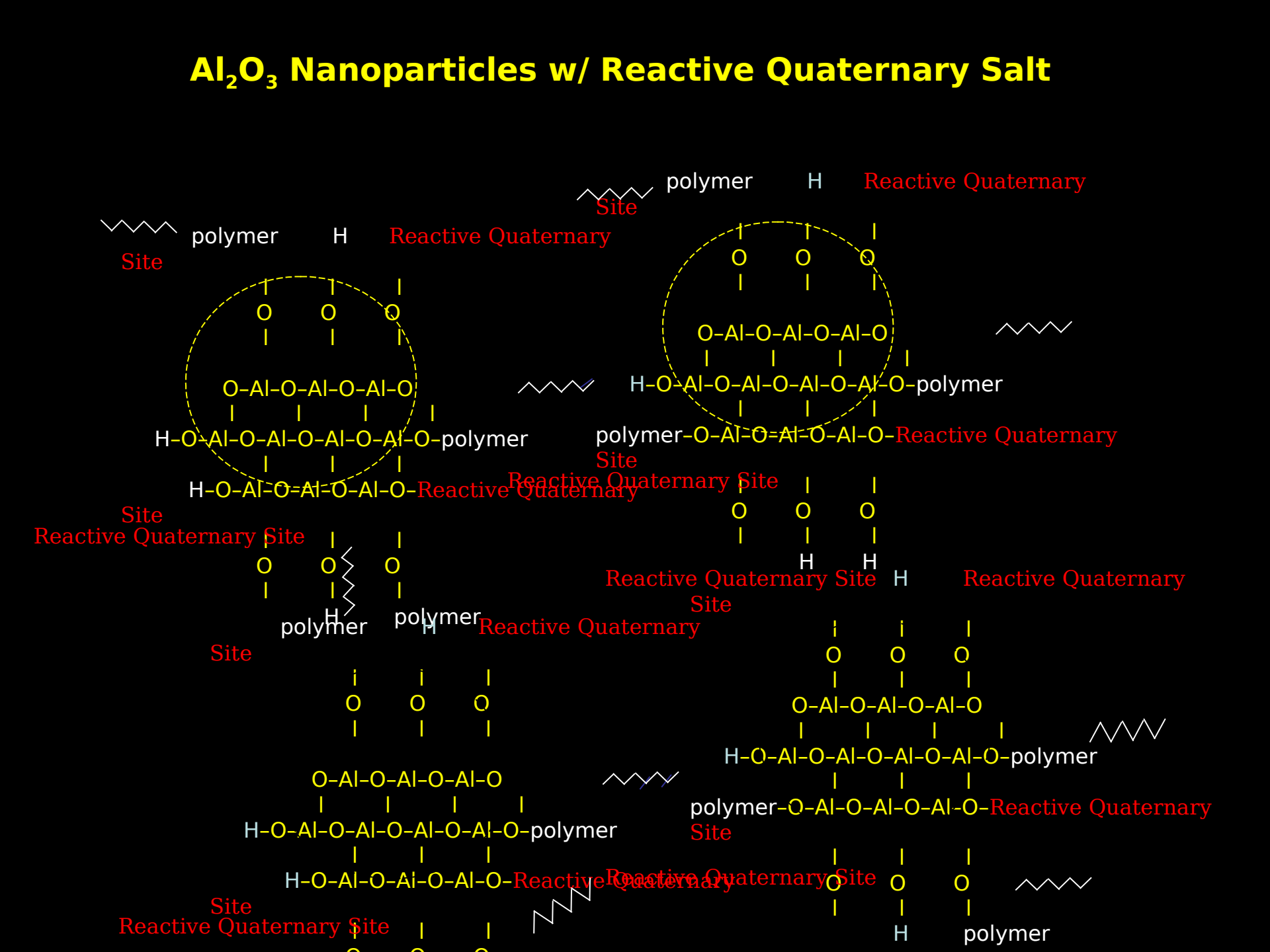
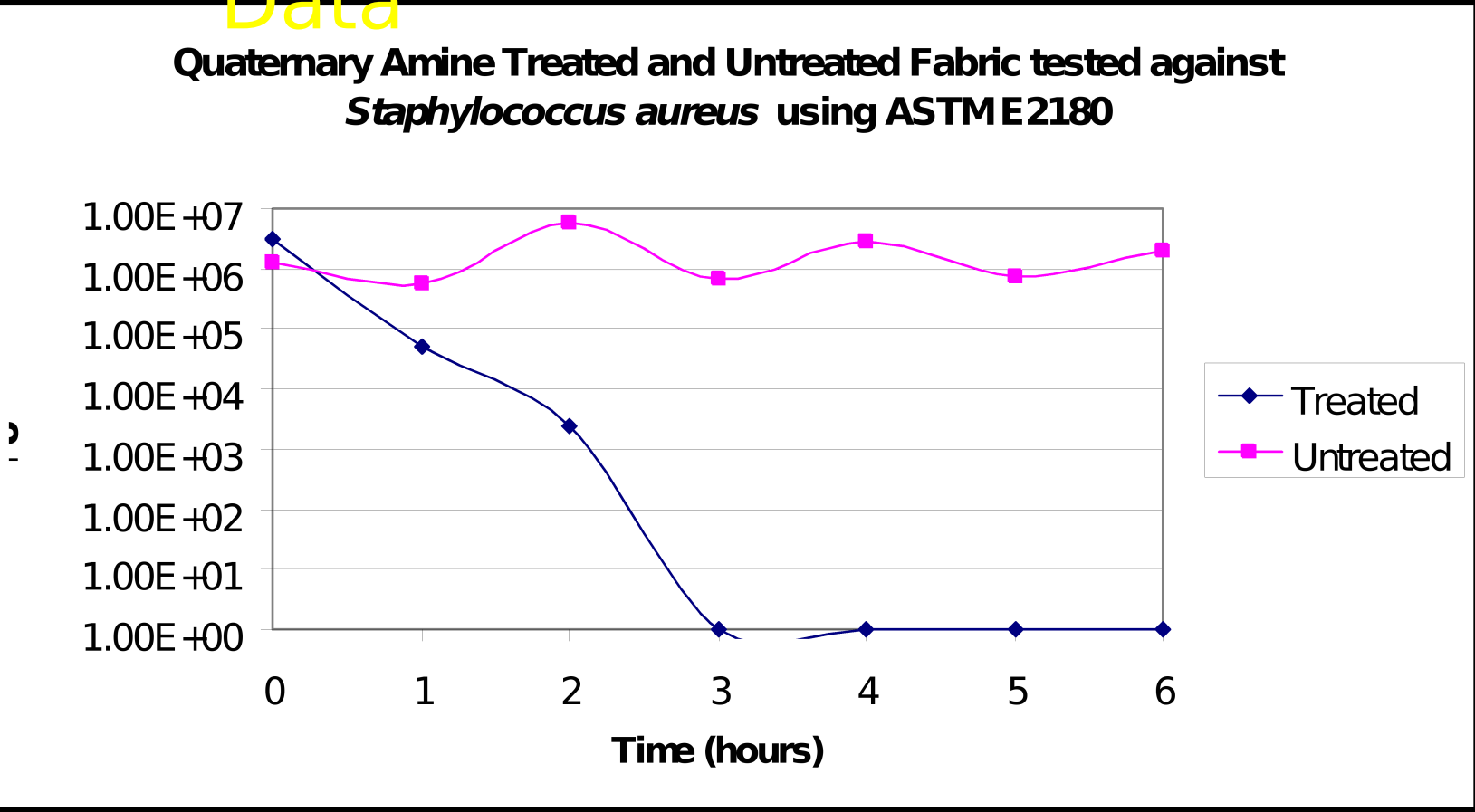
Quaternary Amine Benefits

- No need to recharge (unlike Chloramines)
- Can incorporate into variety of surfaces
- Commonly used in household cleaners
- Non-specific method of kill
  - Will not lead to resistant organisms
  - Disrupts cell membrane / ionic balance

Al_2O_3 Nanoparticles w/ Reactive Quaternary Salt



Quaternary Amine Test Data



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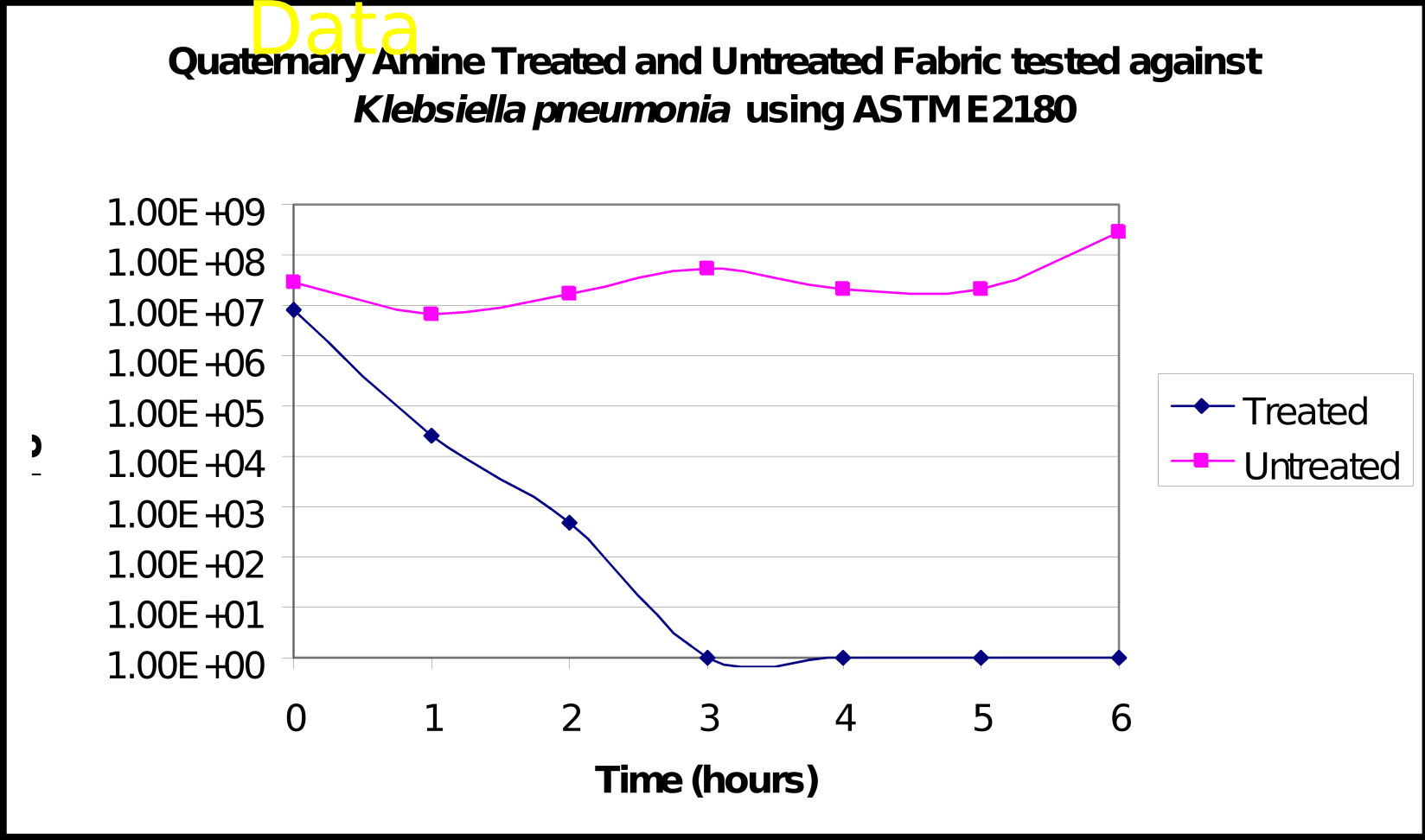

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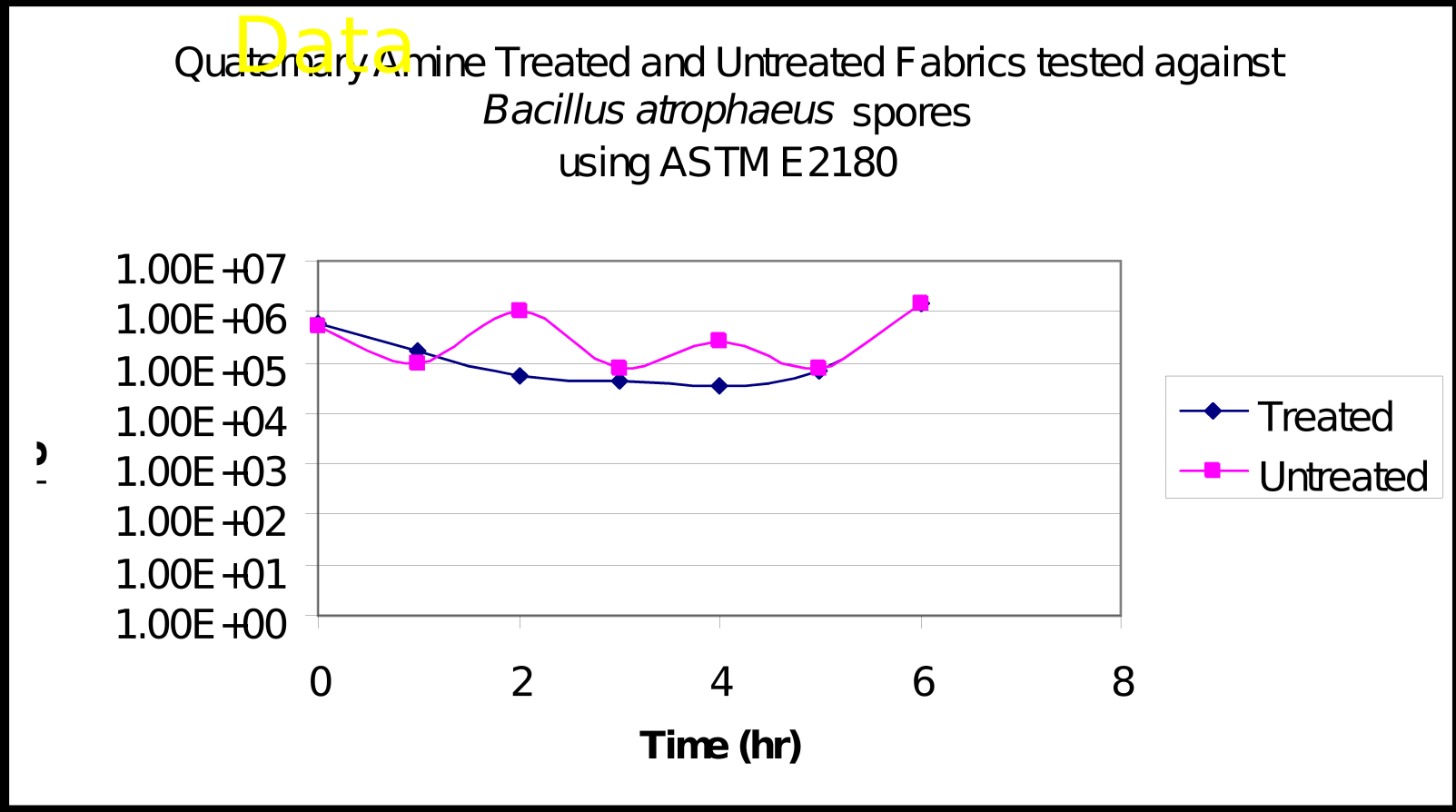

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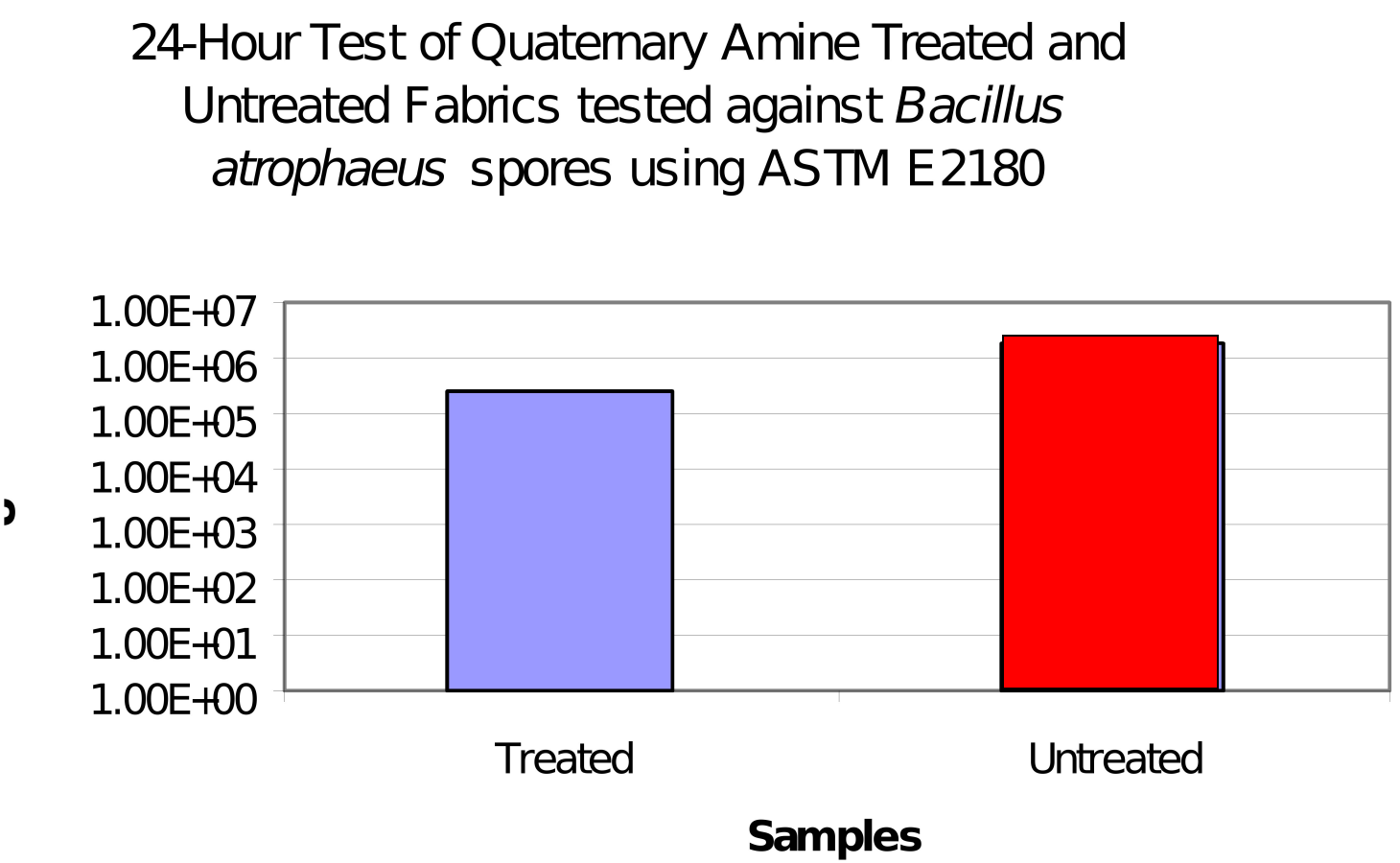

Revised ASTM E-2180-01

- Difficulty using original ASTM protocol
  - Using extremely hydrophobic fabric
  - Could not achieve thin cell suspension
- Created agar/cell slurry
  - Poured slurry onto sterile glass slides
  - Fabric applied to dried slides
- Additional test with aerosol challenge (BATS)

Bioaerosol Testing System (BATS)

- Able to load BG spores directly onto fabric swatches
- Avoids hydrophobic issue

BATS test for *Bacillus atrophaeus* spores on quaternary amine fabrics

Fabrics	Treated **#1**	Treated **#2**	Untreated
Total CFU	6.60E+04	3.60E+04	2.63E+05

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Direction

- Field studies of chloramine technology
  - Ft Drum, NY- June 2003
  - Lackland AFB, TX (37th TRSS) - Nov 2003
  - 823rd SFS (Moody AFB) – Sept 2004
- Quat technology
  - Further textile studies being conducted by AFRL/MLQL
  - Efficacy field study

Questions?